KANSAS DURING THE ICE AGE.

(Address of the Retiring President, Forty-ninth Annual Meeting.)

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IT may safely be assumed that in a presidential address the speaker is to bring forth some fruitage of his personal research. The speaker came to the state nearly ten years ago. He had studied glacial deposits in Missouri, Iowa, Nebraska, South Dakota and North Dakota, or along the Missouri river from its mouth to Bismarck, with the exception of northeastern Kansas. Doctor Haworth soon engaged him to study the glacial deposits of Kansas, and more or less progress has been made each year since. It has been planned to finish this work the present year. Portions of the results have been already read before the Academy, namely, concerning "Drainage of the Kansas Ice Sheet," "Wakarusa Creek," and "Kaw Lake." I invite your attention on this occasion to a comprehensive, popular discussion of my subject without going into detail.

Our subject is "Kansas During the Ice Age." After a preliminary sketch of the different stages of the glacial period in North America, a short review will be given of the facts discovered, with some discussion of their correlation and significance, and finally the whole will be given in a consistent provisional history of the ice age in Kansas.

Preliminary. The Pleistocene epoch was the first epoch of the Quaternary period. It followed the Tertiary period, and closed with the beginning of the present, or recent epoch. It covered the last time when glaciers were prominent over the earth.

In North America, near the beginning of this epoch, snow accumulated many thousand feet in thickness over three centers in Canada, namely, Labrador, Kewatin (west of Hudson's bay), and in the British Columbia Rockies. From each of these centers ice sheets advanced in all directions, but especially toward the south.

Nor was this advance with one maximum or culmination, but with several, at least three or four, advances of primary rank, and more or less marked local culminations, which alternated with either recessions or perhaps disappearance of the ice.

The culminations of ice advances have been named from the states in which their deposits have been most prominent or most satisfactorily studied. Each ice sheet, or spread of the ice, left a sheet of unstratified clays, sand and bowlders, called 'till," and sometimes marginal moraines and other deposits. The stages recognized, in order of time, are:

1. Nebraskan, Jerseyan, or Albertan.
2. Kansan.
3. Illinoisan or Iowan.
4. Wisconsin, with minor subdivisions.

In the recessional stages, alternating with these, were laid down various water-laid gravels and clays, with peat beds and other organic deposits.

It should be remembered that similar deposits were forming more or less beyond the reach of the ice throughout all Pleistocene time.

SIGNIFICANT FACTS.

Topography. The region discussed is a plain about a thousand feet in altitude along the Missouri river on the east, and rising to 1,400 to 1,500 feet along the Big Blue. The bedrock consists of alternating shales and limestones of the Pennsylvanian on the east, with other strata of the Permian and Cretaceous showing in patches along the western margin.

As the prevalent dip of the strata is uniformly of a few degrees to the northwest, the rise of the general upland surface is by a succession of low, broad, gigantic steps, which have become more or less obscured by erosion and the mantle of drift which is thrown over them. The larger streams have cut down valleys 250 to 400 feet deep, and there are few square miles of the upland which are not traversed by watercourses. No basins or lakes occur except on the flood plains of the Missouri and Kansas rivers.

Limit of the Drift. The southwestern limit of drift bowlders and pebbles corresponds approximately to the Big Blue river on the west and of Kansas river on the south, or, more accurately, the line enters from Nebraska a few miles west of the Little Blue at an altitude of about 1,400 feet. It runs about that level, following the general contour southward, first a little west of Washington, thence southeast to the Big Blue, three or four miles south of Irving; thence it follows the west side of the Big Blue, declining in altitude until it reaches the vicinity

of Manhattan at about 1,175 feet. From Manhattan to Wabaunsee it follows a very irregular line at the last-mentioned level. One of the irregularities is that an old channel running west of Manhattan, past the Kansas Agricultural College, carries bowlders several miles to the southwest (and some have been reported as far away as Fort Riley). From a little east of Wabaunsee the limit runs southwest to Mill creek, near McFarland; then along that stream to Maplehill; thence southeast past Dover to the Wakarusa at Auburn; thence along that stream, with declining altitude (except south of Clinton, where it rises to nearly 1,200 feet), it leaves the state near Kansas City at an altitude less than 1,000 feet. This limit includes the drift scattered by channels, and probably lakes, leaving considerable surface within it which is driftless. At the maximum of the ice sheet the drainage of the whole western edge of the great ice sheet from Canada southward must have passed around the ice within this margin, hence, much of the marginal drift was stream-laid and probably some of it scattered in lakes.

The Limits of Till. The horizontal extent of the till cannot be very definitely determined. Though it may reach a thickness of fifty feet or more in places in the northeastern counties, further south and west it becomes very thin and patchy. It was evidently left so by the ice, but erosion has made it still more attenuated. Only scattered bowlders can now be found, where till patches may have once been a few feet in thickness.

With this qualification, the limit of typical till can be given as follows: A few miles east of Marysville, a little east of Irving, a mile west of Fostoria, three or four miles west of Wamego, four or five miles north of Paxico, four miles northeast of Topeka, about ten miles north of Lawrence, a little north of Lenape, and north and east of Kansas City, Kan.

The vertical range of till reaches 600 or 700 feet, the highest point being near Blaine at about 1,500 feet, and the lowest at Kansas City at less than 800. In the four or five northeastern counties of Kansas exposures of redrock near the upland level are rare, because the till covers all, but watercourses which have cut down 50 or 75 feet below usually show numerous exposures of older rocks with till resting on them. In the deep valleys of the creeks till is usually restricted to the higher levels, from 150 to 200 feet above the bottom of the

valleys. In the valleys of the Missouri, Kansas and Big Blue occur patches of till down to within 25 feet of the flood plain, or 40 or 50 feet above the level of the stream.

The Character of the Till. The till where it has been least weathered is a bluish gray with few bowlders and pebbles, and traversed with joints, dividing it into irregular polyhedral blocks. The joints are frequently filled with thin, chalky veins, and the adjacent till is weathered to a yellowish-brown for a thickness of half an inch or more. When the till is weathered, as in most railroad cuts, it is of dull yellowish gray. The bowlders associated with it are from 50 to 90 percent red quartzite from the well-known ledges in Minnesota. The remainder is mostly gray granite, some times much disintegrated, and greenstone of varying texture, which is usually little changed by weathering. Limestone is usually not prominent.

Distribution of Bowlders. Bowlders are remarkably abundant at several points, generally along the western margin, particularly in strips which pass north and south past Fostoria and Blaine; also six miles north of St. George, two or three miles west of Wamego, and four to six miles south of Wamego, along the east side of an old channel leading over the divide from Kansas river to Mill creek. Other very bowldery strips are found along channels leading to the Wakarusa from near Dover and Topeka.

Striæ. Comparatively few cases of striation of bedrock have been found. This is partly due to the lack of thick strata of limestone and partly to shallowness of the overlying soil. Probably surfaces which were once well striated have had the striæ removed by weathering. The following are all the cases which have been observed in Kansas, with some from adjacent territory:

Locality.	*Direction.*
Two miles southwest of Seneca	S. 21° 25° W.
Northeast of Quindaro Park, 117 feet above Missouri bottom	S. 16° W.
Near corner Twenty-fifth street and Sandusky, Kansas City, Kan, 125 feet above the Missouri	S. 12° 24° W.
Two miles east of Lenape, 125 feet above the Kansas	S. 21° E.
One mile north of St. Joseph, 125 feet above the Missouri	S. 26° W.
One mile north of Kansas City, 130 feet above river	S. 79° 24° W.
East part of Kansas City, 100 feet above river	S. and S. 6° E.

Moraines. Although several other observers have reported marginal moraines in Kansas, the writer, after examining

them, is convinced that there are no true moraines in this state. Some were reported west of Washington, but examination proved that there was only a thin scattering of bowlders over Dakota sandstone. West of Wamego and northeast of St. George are found bowldery knolls which might easily be mistaken for a subdued form of a marginal moraine, but the bowlders rest on clays which are probably Carboniferous. The knolls have been brought out by differential erosion. The wide bowldery strip on the divide south of Wamego suggests a concentration of bowlders near the edge of the ice, somewhat as a moraine is formed, but there is no accumulation of till underneath. Southwest of Topeka a few miles are a few bowldery ridges lying just east of Burnett's Mound and trending southeast. These have been quite persistently called moraines, but they are found to consist of stratified gravel, and a short distance farther south they become continuous with similar deposits lying in distinct channels. A bowldery hill near Clinton, which has been called a moraine, proved to have a similar origin.

Stream Deposits. This naturally leads us to consider stream deposits. No esker or kame deposits have been found in Kansas. All such stratified beds lie in channels and not on a ground moraine or till sheet.

The stream deposits associated with the glacial deposits of Kansas may be classified as follows:

1. Higher-level chert gravels.
2. Lower-level chert gravels.
3. Drift-filled channels, which are of three distinct kinds, viz.:
   (1) Channels filled with local drift.
   (2) Channels filled with northern drift, overridden by the ice.
   (3) Channels beyond the limits of the ice.

Higher-level Chert Gravels (Preglacial). One approaching the region from the west would first note a drop toward the east in the general upland surface. This is quite well marked and is covered with chert fragments. This is easily traced to the decomposition of several strata of flinty limestone in the lower part of the Permian. Because this chert breaks in comparatively small fragments it has been carried far eastward by various streams. As this material is insoluble and virtually indestructible, it forms a very perfect protection to the under-

lying beds; hence it forms the capping of prominent terraces along such streams as the Kansas river and Mill creek and others which flow eastward.

The highest chert beds lie from 125 to 150 feet above the level of the present streams. Along the Kansas river the chert gravels show several feet in thickness in the bottom of the old channel west and north of Manhattan. East of the Big Blue the chert lies in detached patches, one a few miles east of the Big Blue, then north and northeast of St. George, again one mile west of Wamego, and northwest and north of that place. It is extensively developed a few miles north of Rossville, and is probably nearly continuous as far as Kiro. The next clear trace of it is north of Fall Leaf, northeast of Lawrence, where it extends widely for three or four miles to the vicinity of Linwood. It is probable that traces of it may be found north of Perry and Williamstown.

An old bank of a channel marked by limestone cobbles is found near Wilder at a corresponding altitude.

Near Atchison, both south and north of the town, is a similar deposit of chert gravel only about 80 feet above the Missouri, and apparently in a channel trending northeast. The lower altitude of the deposit at Atchison agrees with the conclusion, based on other evidence, that it was in a different river system, which had a lower drainage level.

These chert gravels have never been found more than 10 feet in thickness. No northern erratics have been found within them, but they frequently rest upon it. It does not lie in a plain exactly, but varies somewhat in altitude, as we should expect if it marked not only the level of the shore or bars, but also the bottom of the ancient river.

Lower Chert Gravels. Another chert gravel deposit has been discovered and developed at several points, namely, a mile west of St. Marys, east of Rossville, north of Kingville, north of Grantville, northwest and north of Topeka. The bottom of the deposit is 25 or 30 feet above the adjacent bottom lands of the Kansas river. Northern erratics abound in the *upper* half of it, and according to the testimony of a few, they occur to the very bottom, but certainly has not been reached on that point. The gravel and sand strata show thickness of 12 or 15 feet.

Drift-filled Channels. Of these there are two sorts, one mainly filled with local material, mainly limestone; the other filled with northern erratics, consisting largely of sand and gravel. The former, we may suppose, were eroded and filled while the ice was quite distant—near enough to supply water, but too remote, or relatively too low down, to contribute much debris from the load of the glacier. The latter would be close to the ice, or so much below it that drift would be washed into the stream almost constantly.

As the ice sheet advances, streams flowing toward it will become obstructed and ponded. If such ponds fill and overflow, the material first carried by them, remote from the ice, will be of local origin. These channels are apt to be parallel with the edge of the ice, or over a divide in some other direction.

As the edge of the advancing ice sheet approaches the divide it will greatly quicken the action of streams on the further slope, especially if the melting of the ice is rapid, and it is likely to be the more rapid at first because of heat from the newly occupied earth underneath.

As the streams radiating from the advancing ice sheet are swollen the water will increase more rapidly than the debris from the ice is furnished. Two things conspire to this effect: first, the drift is apt to be coarser, and therefore soon dropped; second, the melting of the advancing glacier is more from the upper and cleaner part of the ice than in a receding glacier. As the ice recedes, though the water may increase in volume, material both fine and coarse will be likely to increase also in larger ratio.

Hence, if we have reasoned correctly, radiating streams will be eroded rapidly as the ice approaches; then they will fill up their channels as it becomes nearer. Then they may be covered with the ice and plastered over with till. Later, in the recession of the ice, streams may advance headward and follow courses approximately corresponding to which they occupied before the ice displaced them.

Of the channels filled largely with limestone bowlders we have found two interesting examples. One shows a stratum of bowlders 15 to 20 feet thick, with its bottom about 140 feet above the present Missouri. It extends for several miles along the east side of the Missouri river at Weston, Mo. Its width has not been determined. Mr. F. C. Greene, of the Missouri

Survey, informs me that similar deposits have been found further east. This is as would be expected from our theory, which may be briefly stated as follows: The ice advanced from the northeast. From buried channels and general topography it is inferred that there was a preglacial stream, probably formed by the Platte river of Nebraska, running southeast from the northwest corner of the state of Missouri and joined to the Grande river. The ice coming from the northeast would dam the Platte and pond it about the northeastern corner of Kansas. As the waters rose they would find their way southward across the divide, and as the ice moved further westward one *col* after another would be occupied until the ice should force it to find a higher one, or one that should be permanently followed, and so predetermine the course of the Missouri at that point. The bowlder deposit at Weston seems to represent such a case.

Another similar but less striking example has been noted a mile west of Bethel, on the west half of sections 30 and 31, township 10 south, range 24 east. This apparently crossed the divide between the Kansas and a former tributary of itself. It is approximately on the same level as that near Weston. The concavity of the stream bed indicates a width of about 40 yards.

Both these channels are mainly filled by blocks of limestone from ledges not far away, but mixed with them are perhaps one percent of northern erratics, such as granite and red quartzite. Both have for bedrock Carboniferous strata, and both are in the till-covered region.

The later drift-filled channels are more intimately connected with the till. Some are either underlain or overlain by it, or both. Others being beyond the limit of the till, may be more free from it than those of the earlier channels. From the nature of their relations these channels are not as readily traced. They probably exist in many places where they have not yet been discovered.

One of these drift-filled channels has been discovered east of Seneca. The sand and gravel in it appears to be 20 or 25 feet thick. It lies 60 to 80 feet above the present Nemaha, near by.

Southwest of Sabetha a few miles, and west three miles, are other gravel beds of less thickness and of uncertain relation.

So also along Walnut creek, near Padonia and east of

Hiawatha, other gravel pits have been opened of similar character and age, judging from reports.

Another class of drift-filled channels are those which are mostly beyond the edge of the till, and therefore are much more easily traced. One system of channels of this class is found in the Wakarusa valley. The channels along the north side of the system are most evident because the edge of the ice on the north abounded in northern erratics, and because they have been less subject to erosion than toward the center of the Wakarusa valley. The principal channels may be briefly traced as follows: From Dover to Auburn; another from east of Burnett's Mound, southwest of Topeka; southeastward along Linn creek; and also southward past Pauline. Other patches of larger channels are found along the Wakarusa, south and east of Clinton and southeast of Lawrence.

A somewhat similar channel, though less perfectly filled with gravel and sand, crosses over the divide four to five miles south of Wamego into the valley of Mill creek. It lies along the western edge of the bowldery strip already mentioned, and seems to have been the outlet of the Kaw lake, which will be described in the next section.

Lacustrine Deposits. From the extent of the till and of bowlders it will be seen that the ice sheet filled and crossed the trough of the Kansas river from Wamego to Lecompton. As a result a lake was formed on the west which rose nearly 200 feet above the present level of the river, or about 1,175 feet above the sea. The ice pushed into the lake on the east side, and debris from the ice, as well as material from the Big Blue and upper Kansas and other smaller streams, deposited in this lake deep deposits of sand next the edge of the ice and loesslike silts and clays further west. These beds accumulated to a depth of 100 feet or more. Bowlders were scattered over the basin up to the water level, carried either by icebergs or by shore ice. The channel northwest of Manhattan, being part of the lake, was strewn with bowlders and afterwards partly filled with loesslike silt.

Loess. A thin mantle of loamy clay covers the till in the northeastern part of the state generally. It is rarely if ever ten feet thick, except in the bluffs near the Missouri river. It there has the lighter buff color, but further west it is of a darker reddish tint and more clayey, as though it partook of

the character of the underlying Carboniferous shales. It caps some of the highest points found, and these are often near the Missouri, south of wide bottom lands. The most natural explanation of these facts is that the deposit is mostly of Eolian origin. Possibly some of its lower portion may have accumulated as dust upon the glacier ice before it disappeared. This higher loess is not marked on the map, but may be considered as covering the till generally. It is not recognizable elsewhere.

A similar deposit occurs under very different relations at lower levels along the streams, especially near the larger ones. It may reach a depth sometimes of 75 or 100 feet. It passes into sand at lower levels.

It is typically shown at Kansas City, Kan. Its lower limit is about 25 feet above the present streams. Its upper surface is terracelike, rising at Kansas City, Mo., and Kansas City, Kan., up to 150 feet above the streams. Similar deposits are found at St. Joseph and Leavenworth, also along the Kansas river at Muncie, Edwardsville, west of Holliday, at Bonner Springs, and in other places, perhaps as far west as Topeka. This lower loess, as it may be called, also has a lighter shade along the Missouri river, and a redder cast, and more clayey character along the Kansas.

It evidently is a flood deposit marking an unusually high stage of the streams, since the glaciers left this region. The term loess has also been applied to the silts deposited in Kaw lake and also to that capping lower terraces along the Kansas.

PLEISTOCENE HISTORY OF NORTHEASTERN KANSAS.

The Preglacial Stage. The higher chert gravels are believed to mark the altitude and courses of streams in preglacial time at somewhere about the beginning of the Pleistocene epoch. Accordingly, we believe that at the time the Kansas flowed from 150 to 175 feet higher than at present. Remember that the bottom of the gravels would correspond to the bottom of the present river gravels 40 feet or more below low-water mark. The course of the river ran though the channel northwest of Manhattan, thence east, as is shown on the map; always, so far as known, north of the present river as far east as Kansas City. It probably ran east as far as central Missouri.

The Big Blue and other tributaries had courses similar to those of the present time, but at higher levels.

The Missouri river was not then in existence. The northeastern part of the state, including Atchison and Seneca, probably drained northeast into the Platte-Grande river, as has been already suggested.

The Advance of the Kansan Ice Sheet. From other regions we learn that there was at least one advance of the ice before the Kansan, viz., the Nebraskan; but we have no evidence that it affected Kansas, except that streams may have deepened their channels somewhat lower than the higher-level chert gravels. After the Nebraskan ice sheet, and the following stage of Aftonian gravels, came the Kansas ice sheet, probably from the Kewatan center by way of the Des Moines valley—that is, from the northeast.

One of the first effects of this advance was the damming of the Platte-Grande river somewhere near Stanberry, Mo. The result would have been a lake, which filled the valley of the Nemaha and other streams in northeastern Kansas. The water rose until it found a way over the divide southward. This condition probably caused the bowldery stratum near Weston, Mo., inaugurating the course of the present Missouri. The bowlder-filled channel west of Bethel may have been part of a similar stream which was not permanently followed.

Later the ice advanced, causing the water to rise until higher *cols* were reached and occupied by small streams such as deposited gravels near Seneca, Sabetha, Hiawatha, and other points. The larger tributaries of the Kansas and Big Blue, augmented with more water but not at first with corresponding amounts of debris, eroded down to the level of the lower chert gravel; in them the higher gravels were rearranged at lower levels, and in the later stages, if not in the earlier, northern erratics were intermixed.

The larger streams at that time flowed about 75 to 100 feet higher than at present.

The Maximum Extent of Kansan Ice. When the ice reached its maximum extent, as has already been mentioned, it filled the trough of the Kansas river from Wamego to Lecompton and pushed on until its edge lay upon the divide south—a few miles north of the limit of the drift as already given.

Kaw lake filled and overflowed through its outlet into Mill creek, and across the next divide to Mission Creek, where, at Dover, a small stream broke over into the valley of the Waka-

rusa. Most of the water skirted the edge of the ice at Shunganunga creek, southwest of Topeka, where most of it ran over the divide past Pauline and southeast to the Wakarusa. Another stream broke over the divide near the head of Deer creek. All these are marked by bowlder-filled channels, or by terraces. They are about 100 feet higher than the present streams.

On similar evidence, though considerably less complete, we believe another lake was formed by the ice shutting off the Big Blue at Irving. This would explain the distribution of bowlders west of the Little Blue in Washington county. In this the water rose probably, for a short time only, about 1,400 feet above the sea.

As the water sought a way around through the Wakarusa valley it may have cut across the valleys and intervening divide of some southern tributaries of the Kansas. Waterfalls and rapids doubtless marked the early stages of this stream. The unusual height of bowlders south of Clinton may have been due to local ponding. The narrow valley southwest of Lawrence may have been attended with a fine waterfall, and the width of the valley just east is doubtless a result of the easy erosion of the thick Lawrence shales.

The ice sheet evidently lay so close to the bluff at Kansas City, Mo., that the Kansas river flowed for a time through the valley south of the central part of the city, although, very strangely, but few northern erratics have been found in the valley thus far.

There is some evidence that the ice sheet in Kansas was more or less lobular in form, at least after it passed over the divide into the Kansas valley. One lobe passed down the Black Vermillion to Irving, another down the Red Vermillion to Wamego, another down the Big and Little Soldier to Topeka, another down the Grasshopper to Perry, and another down the Big Stranger to Linwood and Lenape. All these, except the first, were pretty closely merged together, but between the last mentioned, which reached east of Edwardsville, and another lobe, which pushed into the western part of Kansas City, Kan., there is quite a reëntrant angle which is fairly driftless. It will be noticed that the striæ agree with this view.

The culmination of the Kansan stage did not last very long.

The age was not stationary long enough to form a moraine, and the till deposited was very thin. The ice was comparatively thin. It did not grind the underlying rocks with much pressure.

In the Aftonian gravels, which were deposited after the retreat of the Nebraskan ice sheet, in Western Iowa, there are found the fossil remains of numerous interesting mammals, including the American mammoth, one or two species of mastodon and of horses, a large bison, a musk ox, and of other subarctic animals. The remains of some of these have been found in the gravels of Kansas. For example, a mammoth tooth from near Hiawatha; a bison west of Atchison; and near Lawrence, but of uncertain age, the skull of a horse, bison and large cat; but unfortunately the exact source of these fossils has not been determined.

As we speak of the novel state of affairs of the ice age, some are curious to know how thick was the ice, whether it was clear or mixed largely with debris, and how fast it moved. Rational replies can best be given by learning what conditions exist today in a closely similar case in southern Greenland, for there the land rises to about two thousand feet above the sea, only a little higher than the region we have been considering. Those who have studied the matter inform us that above a few feet in the lower part of the ice, the ice sheet is spotless; also that its upper surface rises at the rate of from 45 to 75 feet per mile, but that the rate is greater near the edge than further back. At this rate, when the ice reached beyond Topeka at its maximum extent, at the northeastern corner of Kansas, 75 miles away, it was 3,375 to 5,600 feet thick.

The velocity of the ice at certain outlet points on the coast of Greenland has been reported from 60 to 100 feet per day. This was pouring into the sea. On the land it would move more slowly. The velocity reported was for midsummer. It is less than one-fourth as much in the wintertime.

The Recession of the Ice. For some unknown reason, whether diminished altitude or greater heat from the sun, or more carbon dioxide in the air, the climate became warmer. The ice mantle could no longer resist the withering effects of the south wind, and began soon to gradually retreat by shedding floods of water.

As soon as the edge of the ice had withdrawn from the

southern side of the trough of the Kansas river, Kaw lake found an outlet eastward and ceased to flow over into Mill creek, and the Wakarusa dwindled to an insignificant stream. The Kansas river was for a time a more magnificent stream than ever before. Lake Washington had probably emptied itself before Kaw lake began to decline.

Much of the sand and mud which had accumulated in the latter was swept away and contributed to terraces at several points in the valley below. For example, the capping of the lower chert gravels, the high terrace northwest of Lawrence and northeast of Mud creek, also south of Eudora. Meanwhile the ice had withdrawn from Kansas City, Mo., so that the Kansas and the newly formed Missouri had their present courses, but at a higher level. The most thrilling chapter of the story has been told. What remains is a rapid decline to the present commonplace conditions.

Kansas during the Illinoian and Iowan Stages. After the Kansan, the western side of the ice drained entirely through the Missouri, so far as Kansas was concerned. In other words, the Big Blue ceased to receive any drainage from the ice.

We know no reason for thinking that the streams of that time were any larger than those at present, except the Missouri, and that may have received little, for the relation of the Iowan to it has not been determined.

The streams of Kansas, therefore, simply cut down their channels, much as at present, but were still considerably higher than at present. Meanwhile the loess overlying the till was slowly accumulating.

The Wisconsin Stage. This stage saw extensive ice sheets filling the James river valley of South Dakota and the Des Moines valley in central Iowa. Both contributed largely to the Missouri.

In the recession from the Wisconsin stage the Missouri was probably greatly flooded and carried abundance of silt. This would explain the thick silt deposits, which have been called the lower loess at Kansas City. The Kansas river was swollen by backwater, and formed similar terraces on a smaller scale. This was the last prominent event of the story. With the decline of the flood closed the last chapter of the ice age, so far as Kansas was concerned.

CONCLUSION.

In conclusion, a few words on two points: First, to anticipate some questions which are apt to be asked after such discussion; second, problems which are still unsolved.

The time since the close of the Wisconsin is estimated by some to be from 10,000 to 15,000 years, and from the culmination of the Kansan ten to fifteen times that.

Chamberlain's conclusion, after a careful consideration of the rates of advance and recession of the ice, and the relations and rates of erosion of such gorges as the Niagara and the Mississippi near St. Paul, gives 20,000 to 80,000 years since the recession of the Wisconsin ice, and 300,000 to 1,360,000 since the Kansan.

Was man in existence at that time? Some claim to have evidence that men lived in North America, even in Kansas, before the close of the glacial period. The "Lansing man" has been thought by some to have lived during the recession of the Kansas ice, but at present the weight of evidence seems to show that man was not contemporaneous even with the later stages of the Wisconsin ice in North America, and that the "Lansing man" may have lived less than a thousand years ago.

Finally, it should be frankly admitted that several problems still unsolved can be pointed out:

First, we have postulated glacial lakes to explain the remotely scattered bowlders in Washington county and those of extraordinary height south of Clinton. May they not be remnants of a still older ice advance, or in other words, may they not be traces of the Nebraskan till sheet?

Second, the course of the Platte-Grande river has been only partially determined.

So also in several other cases only possibilities have been indicated, and our statements are to be taken provisionally. As the state is more and more developed, excavations will be made which may throw floods of light on these and other questions. Twenty years from now the glacial history of Kansas, we may hope, will be much clearer and more complete. I shall be satisfied if I have contributed my mite, as a pioneer explorer.

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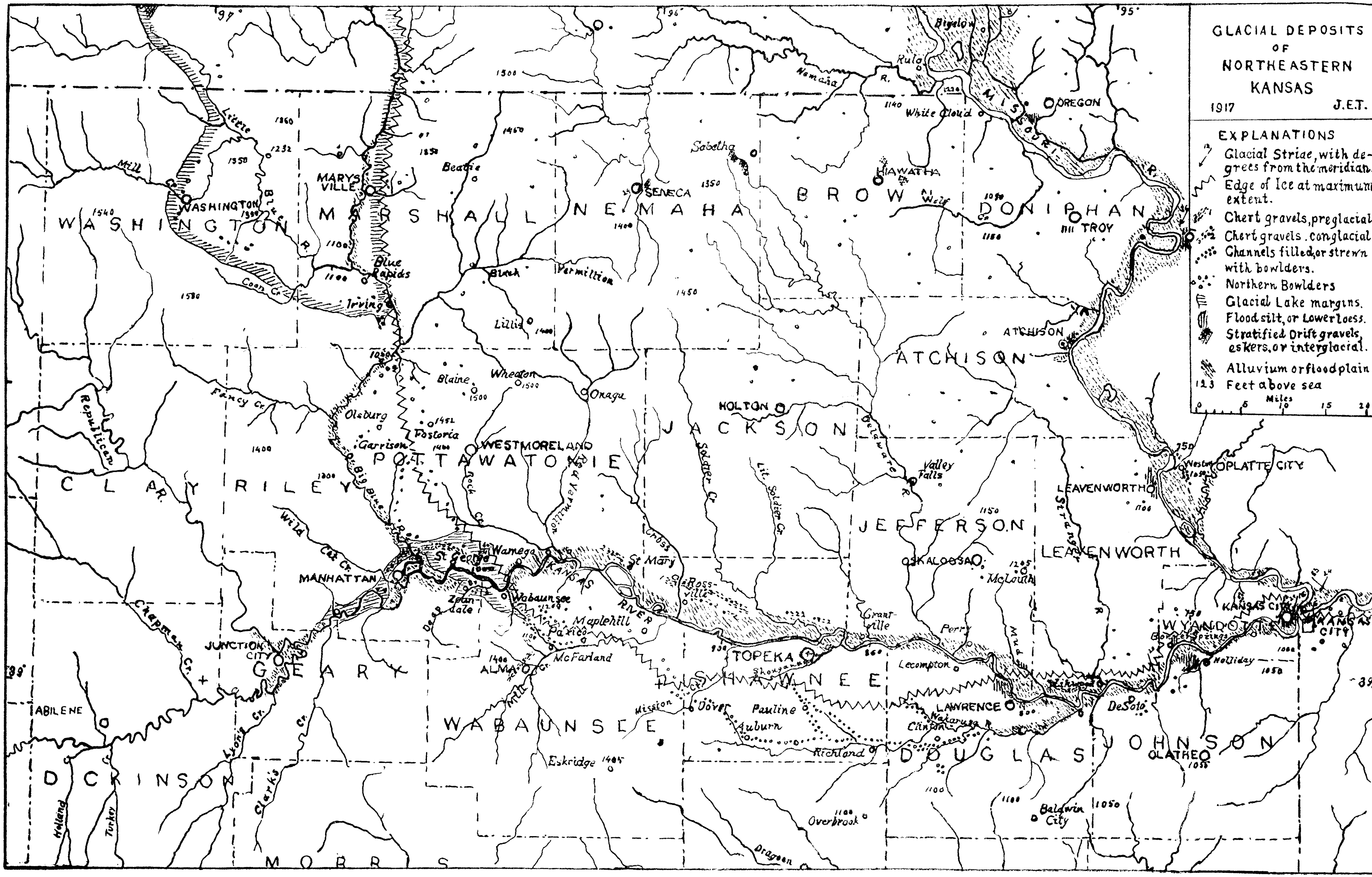
GLACIAL DEPOSITS
OF
NORTHEASTERN
KANSAS
1917 J.E.T.
EXPLANATIONS
Glacial Striae, with degrees from the meridian.
Edge of Ice at maximum extent.
Chert gravels, preglacial.
Chert gravels, conglacial.
Channels filled, or strewn with bowlders.
Northern Bowlders
Glacial Lake margins.
Flood silt, or Lower loess.
Stratified Drift gravels, eskers, or interglacial.
Alluvium or floodplain
Feet above sea
Miles
0 5 10 15 20
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
CLAY
RILEY
POTTAWATONIE
JACKSON
ATCHISON
JEFFERSON
LEAVENWORTH
GEARY
WABAUNSEE
SHAWNEE
DOUGLAS
JOHNSON
WYANDOTTE
DICKINSON
MORRIS
WASHINGTON
MARYSVILLE
SENECA
HIAWATHA
TROY
OREGON
ATCHISON
HOLTON
WESTMORELAND
MANHATTAN
JUNCTION CITY
ABILENE
TOPEKA
LAWRENCE
OSKALOOSA
LEAVENWORTH
PLATTE CITY
KANSAS CITY
OLATHE
ALMA
Blue Rapids
Irving
Beattie
Sabetha
White Cloud
Rulo
Bigelow
Lillis
Blaine
Wheaton
Onaga
Olsburg
Garrison
Fostoria
Wamego
St. George
Zeandale
Wabaunsee
Maplehill
Paxico
McFarland
Eskridge
St. Mary
Rossville
Valley Falls
McLouth
Grantville
Perry
Lecompton
Dover
Mission
Pauline
Auburn
Richland
Clinton
Overbrook
Baldwin City
DeSoto
Holliday
Bonner Springs
Republican
Little Blue R.
Mill
Coon Cr.
Black Vermillion
Big Blue R.
Fancy Cr.
Wild Cat Cr.
Chapman Cr.
Lyons Cr.
Clarks Cr.
Holland
Turkey
Rock Cr.
Red Vermillion
Cross Cr.
Soldier Cr.
Lit. Soldier Cr.
Delaware R.
Stranger
Kansas River
Missouri R.
Nemaha R.
Wolf Cr.
Mud
Wakarusa R.
Dragoon
97°
96°
95°
39°